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(54) **"Testing head having vertical probes for semiconductor integrated electronic devices."**

(57) The invention relates to a vertical-probe testing head (100), of a type that comprises at least a first and a second plate-like holder (12A, 12B) respectively provided with at least one guide hole (13A, 13B) for receiving at least one contact probe (14), having at least one contact tip (15) adapted to establish mechanical and electrical contact to a corresponding contact pad (16) of an integrated electronic device (17) to be tested and being deformed in a deflection region (22) of the probe (14) located between the plate-like holders (12A, 12B) as the contact tip (15) abuts onto the contact pad (16).

Advantageously in this invention, the contact probe (14) has, located at said contact tip (15), at least one rigid arm (20) extending laterally from a body (21) of the contact probe (14) and terminating in the contact tip (15). In particular, the rigid arm (20) is adapted to offset a contact point of the probe (14) with its corresponding contact pad (16) from a longitudinal axis (A-A) of the contact probe (14).

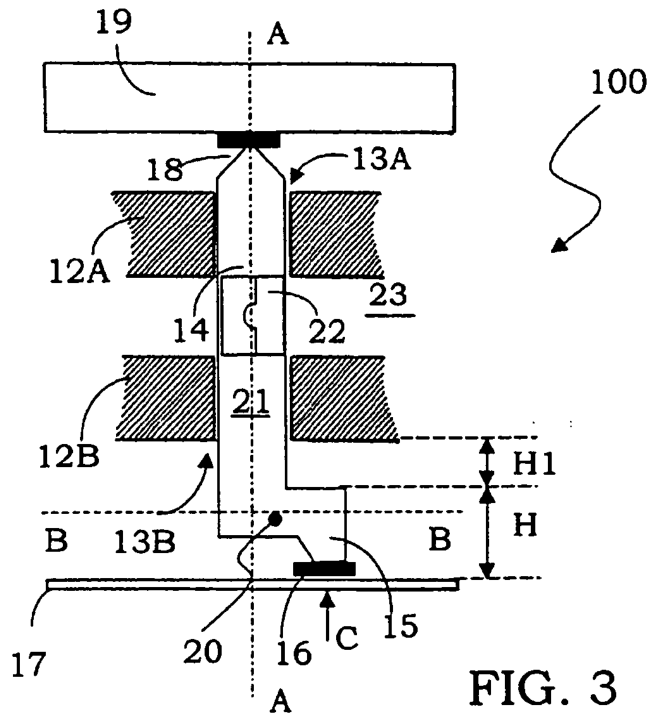

FIG. 3

EP 1 243 931 A1

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Description

Field of Application

[0001] The present invention relates to a testing head having vertical probes and used to test a plurality of semiconductor-integrated electronic devices incorporating so-called contact pads.

[0002] The invention specifically relates to a testing head having vertical probes of a type which comprises at least a first and a second plate-like holder, or die, respectively provided with at least one guide hole adapted to receive at least one contact probe formed with a contact tip suitable to establish mechanical and electrical contact to a corresponding contact pad of an integrated electronic device to be tested, said probe being deformed in a deflection region of said probe located between said plate-like holders as said contact tip abut said contact pad.

[0003] The invention relates, particularly but not exclusively, to a testing head having vertical probes for testing semiconductor-integrated electronic devices, and this description will make reference to that field of application for convenience of illustration only.

Prior Art

[0004] As is well known, a testing head is basically a device suitable to electrically interconnect a plurality of contact pads of a semiconductor-integrated electronic device and corresponding channels of a testing machine arranged to perform the tests.

[0005] Integrated electronic devices are factory tested in order to spot and reject any circuits that show out to be already defective during the manufacturing phase. The testing heads are normally employed to electrically test the semiconductor-integrated electronic devices "on wafer", before cutting and mounting them in a chip package.

[0006] A testing head having vertical probes comprises at least a pair of parallel plate-like holders placed at a given distance apart to leave an air gap therebetween, and a plurality of specially provided movable contact elements.

[0007] Each plate holder, referred to as a die in the art and throughout this specification, is formed with a plurality of through-going guide holes, each hole in one of the dies corresponding to a hole in the other die and guiding a respective contact element, or contact probe as the element will be called through this specification and the appended claims, for sliding movement therein. The contact probes are usually cut from wire stock of some special alloy having good electrical and mechanical properties.

[0008] A good electrical connection of the testing head contact probes to the contact pads of an integrated electronic device to be tested is achieved by urging each contact probe onto the respective contact pad. This results in the movable contact probes becoming flexed in the air gap between the two dies.

[0009] Testing heads of this type are commonly known as "vertical probes".

[0010] Briefly, known testing heads have an air space where the probes are allowed to flex, such a flexion action being eventually assisted by suitable design of the probes or their dies, as shown schematically in Figure 1.

[0011] As shown in Figure 1, a testing head 1 comprises at least an upper die 2 and a lower die 3, both dies being formed with through-going upper guide hole 4 and lower guide hole 5, respectively, in which at least one contact probe 6 slides.

[0012] The contact probe 6 has a contact end or tip 7. In particular, the contact tip 7 is caused to abut against a contact pad 8 of an integrated electronic device to be tested, thereby establishing an electrical contact between said device and a testing apparatus (not shown) that has said testing head as end element.

[0013] The upper and lower dies 2 and 3 are suitably separated by an air space 9 in which the contact probes 6 are allowed to deform or flex in normal operation of the testing head, i.e. upon the testing head coming in contact with the integrated electronic device to be tested. The upper and lower guide holes 4 and 5 are both sized to guide the contact probe 6.

[0014] Figure 1 schematically shows a testing head 1, which mounts loose-fitting probes and is associated with a micro-contact strip or space transformer shown schematically at 10.

[0015] In this case, each contact probe 6 has another contact tip toward a plurality of contact pads 11 of the space transformer 10. The electric connection of the probes to the space transformer 10 is assured same as the connection to the integrated electronic device to be tested, i.e. by urging the probes 6 onto the contact pads 11 of the space transformer 10.

[0016] A major advantage of a testing head 1 with loose-mounted contact probes is that one or more faulty probes 6 in the set of probes, or the whole set, can be replaced more conveniently than in testing heads that have fixed probes.

[0017] In this case, however, the upper and lower dies 2 and 3 should be designed to ensure that the contact probes 6 will be held in place even when no integrated electronic device is abutting their contact tips 7 for testing, or when a probe set is removed for replacement purpose.

[0018] The deformed pattern of the probes and the force needed to produce the deflection depend on several factors, namely:

- the distance between the upper and lower dies;
- the physical characteristics of the alloy from which the probes are formed; and
- the amount of offset between the guide holes in the

upper die and the corresponding guide holes in the lower die, as well as the distance between such holes.

[0019] It should be noted that, for the testing head to perform properly, the probes should be allowed a suitable degree of free axial movement within the guide holes. In this way, the probes can also be taken out and replaced individually in the event of a single probe breaking, with no need to replace the whole testing head.

[0020] All these features are, therefore, to be taken into due account in the manufacture of a testing head, given that a good electric connection between the probes and the device to be tested is mandatory.

[0021] Also known is to use contact probes having a pre-deformed shape even when the testing head 1 is not contacting the device to be tested, as in the probes 6b, 6c and 6d shown in Figure 2A. The pre-deformed shape effectively helps the probe to correctly flex during its operation, i.e. upon contacting the integrated electronic device to be tested.

[0022] Conventional testing heads inherently place limits on the distance to be lowered between two adjacent probes 6, while the technological development and the chip miniaturisation continuously press to reduce the distance between centres of two contact pads 8 of an integrated electronic device to be tested, this distance being known as the pitch distance of the pads.

[0023] Thus, a minimum *pitch,* in the sense given above, will be dependent on the layout and the dimensions of the probes 6, according to the following relation:

$$Pitch\text{min} = \text{E} + 2\text{Amin} + \text{Wmin}$$

where Amin=(F - E)/2 and where, as shown in Figure 2B, which is a sectional view through part of a testing head 1 according to the prior art:

Pitchmin is the minimum pitch or distance between centres of two adjacent contact pads 8 of the integrated electronic device to be tested;

E is the dimension of the cross-section of the probe 6. For example, in probes having a circular cross-sectional shape, the dimension used for computing the minimum pitch would be the cross-section diameter value of the probe 6, where the probe has a square cross-sectional shape, while in probes having a rectangular cross-sectional shape, the dimension used for computing the minimum pitch would be the minor side or the major side of the rectangular cross-section of the probe 6, depending on the chosen arrangement for positioning the contact probes;

[0024] In particular, Figures 2C, 2D, 2E and 2F are top plan views of a testing head portion comprising contact probes 6 having a circular cross-sectional shape (Figure 2C), a square cross-sectional shape (Figure 2D) and a rectangular cross-sectional shape (Figure 2E and 2F, in mirrored configurations) respectively.

Amin is the minimum distance between a probe 6 and its guide holes 4 e 5 that allows the probe to slide freely in the guide holes 4, 5 during normal operation of the testing head;

Wmin is the minimum wall thickness allowable between one guide hole 4, 5 and the following, in order to guarantee the testing head 1 to be an adequately strong structure; and

F is the dimension of the cross section of a guide hole 4.

[0025] Current vertical technologies, usually with circular cross-sectional shaped probes, achieve a reduction of the pitch value by reducing the dimensions, and especially reducing the minimum dimension E (being the minimum diameter for probes having a circular cross section) of the probes 6. The other factors in the above relation are set practically by technological limitations to the manufacture of the testing head.

[0026] The underlying technical problem of this invention is to provide a testing head for microstructures, which comprises probes designed to deform upon coming in touch with contact pads in order to establish a good electric connection to an integrated electronic device to be tested, and adapted to allow a substantial reduction in the distance between contact tips and thus a reduction in the pitch distance between contact pads of integrated electronic devices to be tested.

Summary of the Invention

[0027] The principle on which this invention stands is to provide a testing head with a plurality of vertical probes having at least a rigid end portion extending laterally with respect to the contact probe body.

[0028] Based on this principle, the technical problem is solved by a testing head as previously indicated and defined in the characterising portion of Claim 1.

[0029] The features and advantages of the testing head according to this invention will be apparent from the following description of embodiments thereof, given by way of non-limitative examples with reference to the accompanying drawings.

Brief Description of the Drawings

[0030] In the drawings:

Figure 1 shows schematically one embodiment of a testing head according to the prior art;

Figure 2A shows schematically modified embodiments of the testing head of Figure 1;

Figure 2B is a schematic cross-sectional view taken through a portion of the testing head of Figure 1;

Figures 2C to 2F are schematic top plan views of a portion of the testing head according to the prior art with probes having different shapes;

Figure 3 shows schematically a testing head according to the invention;

Figures 4A to 4F are schematic top plan views of some layouts for plural contact probes in the testing head of Figure 3;

Figures 5 and 6 show schematically modified embodiments of the testing head of Figure 3; and

Figures 7 to 9 show schematically different arrangements contact probes-guide holes adapted to raise the frictional drag between them.

Detailed Description

[0031] With reference to the drawings, particularly to Figure 3 thereof, a testing head according to the invention, designed for contacting an electronic integrated device to be tested, is shown generally at 100 in schematic form.

[0032] For simplicity, only the testing head portion that comprises two plate-like holders or dies for the movable contact probes is shown, it being understood that the testing head of this invention could accommodate a range of different dies and movable probes.

[0033] The testing head 100 has an upper die 12A and a lower die 12B, both formed with guide holes 13A, 13B, respectively, and adapted to receive a contact probe 14.

[0034] The contact probes 14 have contact tips 15 arranged to abut onto a plurality of contact pads 16 of an electronic integrated device, shown schematically at 17, to be tested.

[0035] In the embodiment of Figure 3, the testing head 100 is shown to include loose-mounted probes that have a further contact tip 18 at another end for contacting a micro-contact strip or space transformer 19. It should be understood, however, that the testing head 100 could be provided with fixed probes instead.

[0036] Advantageously according to the invention, each contact probe 14 is formed with a rigid arm 20, extending laterally from a body 21 of the probe 14. In particular, the rigid arm 20 extends along a perpendicular or otherwise sloping direction with respect to the probe 14, i.e. has a longitudinal axis B-B lying perpendicularly or at an angle to a longitudinal axis A-A of the contact probe 14. The arm 20 is terminated with the contact tip 15 of the probe 14 for abutting the contact pads 16 of the electronic integrated device 17 to be tested.

[0037] Accordingly, the point where the tip 15 of the probe 14 meets the pad 16 will be offset from the longitudinal axis A-A of the probe 14.

[0038] Advantageously according to the invention, the arm 20 is made rigid, and the probe 14 is designed to deform in a different region, called the deflection region 22, of its body 21.

[0039] In particular, H1 is the distance between the rigid arm 20 and the lower die 12B and corresponds to the maximum overtravel allowed to the probe 14, while H is the height of the rigid arm 20 extending laterally with respect to the body 21 of the probe 14.

[0040] Advantageously, as will be shown in a greater detail in the following description, the testing head 100 according to the invention allows a reduction in the minimum pitch value for the contact tips 15, thus allowing the testing of integrated electronic devices having contact pads with contact centres C really close, i.e. a really reduced pitch value.

[0041] By offsetting the contact tips 15 from the longitudinal axis A-A of the corresponding contact probes 14 and suitably orienting the probes, the contact probes 14 can be located in alternatively opposed positions with respect to the contact pads 16, thus increasing the area allowed for providing the guide holes.

[0042] Therefore, the minimum pitch distance between tips of adjacent probes can be reduced, as illustrated by the non-limitative examples of Figures 4A to 4F.

[0043] The minimum pitch value can be further reduced by using arms with different lengths, as shown schematically in Figure 4B, and/or slenderising the end portions of the arms 20, as shown schematically in Figure 4C and 4D.

[0044] It should be noted that Figure 4D shows an arrangement for guide holes having a rectangular cross-section whose major side is parallel to the X-X axis of the contact pads, while in Figures 4A and 4A such axis are perpendicular to each other.

[0045] Figure 4E shows a miscellaneous guide holes arrangement, to be used particularly when the contact pads are provided along all four sides of the chip to be tested.

[0046] Finally, Figure 4F shows a modified guide holes arrangement, to be used too when the contact pads are provided along all four sides of the chip to be tested.

[0047] In particular, the adjacent probes 14 are located in alternatively opposed positions with respect to the contact pads 16 and having a sloping symmetry axis with respect to the alignment axis Y-Y of the contact pads 16, such axis defining a pre-determined angle, in a preferred embodiment equal to 45°.

[0048] Advantageously according to the invention, the value Pitchmin of minimum pitch is given as:

$$\text{Pitchmin} = S + \text{AIRmin}$$

where $S \leq E$ and, as shown schematically in Figures 4A to 4D:

Pitchmin is the minimum pitch, i.e. the least distance between centres of two adjacent contact pads 16 of the electronic integrated device to be tested;

S is the cross-section dimension of the tip 15 of the contact probe 14;

AIRmin is the minimum distance between two adjacent arms; and

E is the cross-section dimension of the contact probe 14.

[0049] In particular, Figures 4C and 4D show that the value of S can be made much smaller than E by suitably slenderising a part of or the entire end portion of the arm 20.

[0050] From the above described examples, it can be noted that it is especially advantageous if the contact probes 14 have non-circular cross-sectional shapes. In a preferred embodiment, a probe 14 with a rectangular cross-section is provided by way of example. The corresponding guide holes 13A and 13B are here to also have a rectangular cross-sectional shape, so that the probes 14 passed through them are always oriented for proper engagement with the contact pads 16 on the electronic integrated device 17 to be tested.

[0051] Rectangular cross-section holes allow the probe spacing to be further reduced form circular ones, resulting in a still smaller value for the minimum pitch, as shown in Figures 4A to 4F.

[0052] In addition, the compressive deflection of a non-circular cross-section probe 14 in its deflection region 22, as the probe 14 is abutted against the electronic integrated device 17 to be tested, can be controlled much better because the deformation will take place in a given plane.

[0053] In this case, the probe orientation and precise positioning of the contact tip 15 on the contact pad 16 is ensured by the accurate orientation of the rectangular cross-section guide hole 13A preventing the probe 14 therein from turning.

[0054] The deflection region between the dies can be provided by any of the techniques commonly employed for vertical contact testing heads. As an example, the deflection region may be at least one air space between at least two dies that are either aligned or offset and have their guide holes formed with a straight or non-straight cross-sectional shape; in this region the probes may be straight, pre-bent, or have pre-deformed portions to encourage deflection upon contact.

[0055] Figure 5 shows a testing head 100 comprising a plurality of contact probes 14 having a rigid arm 20 with a slenderised shape and a sloping symmetry axis B-B with respect to the symmetry axis A-A of the body 21 of the probe 14.

[0056] In this Figure, H1 is the maximum overtravel allowed to the probe 14, while H is the height of the rigid arm 20 extending laterally with respect to the body 21 of the probe 14.

[0057] Figure 6 shows by way of a non-limitative example a testing head 100 comprising three dies 12A, 12B and 12B defining a first 22A and a second deflection region 22B.

[0058] The testing head of Figure 6 allows to use contact probes 14 having a greater length than the testing heads shown in Figures 3 and 5, thus facilitating the corresponding manufacturing process.

[0059] In a more general case, it is possible to define N deflection region using N+1 dies.

[0060] In such a case, it should be noted that the N+1 dies can be opportunely offset in order to facilitate and guide the deflection of the probes 14 in a particular direction within the respective deflection regions 22.

[0061] As a further example, where the testing head comprises loose-mounted probes, the risk of probes dropping out of the dies can be minimised by increasing the frictional drag of the contact probes 14 through the dies 12A and 12B.

[0062] For this purpose, the dies are offset a greater or lesser amount, such that their corresponding sets of guide holes are aligned together to a greater or lesser extent along normal directions to the dies.

[0063] It would be further possible to use dies provided with straight or non-straight guide holes, or even straight or pre-deformed contact probes.

[0064] Advantageously according to the invention, the frictional drag of the probes 14 through the guide holes 13 is obtained by rotating the guide holes of at least one of the dies of a suitable angle, indicated as α in the example shown in Figure 7, with respect to the corresponding guide holes provided in the other dies of the testing head.

[0065] Alternatively, it is possible to made guide holes having slightly sloped axis in at least one of the dies, as shown in Figure 8.

[0066] Finally, advantageously according to the invention, an increased frictional drag of the probes 14 through the guide holes 13 is obtained by using guide holes having a suitable form in at least one of the dies, in order to elastically deform the contact probe, for example along its cross-sectional axis, as shown in Figure 9.

[0067] Alternatively, it is possible to pre-deform the body 21 of the probes 14 along its cross-sectional or longitudinal axis.

[0068] Finally, in order to further reduce the risk of the contact probes dropping out of their guide holes, an elastic film may be applied to either die in any of the embodiments described hereinabove.

[0069] In conclusion, the testing head 100 according to the invention has, unlike vertical-probe testing heads according to the prior art, its contact probes 14 deformed substantially lengthwise and offset with their longitudinal axes from their contact points on the contact pads 16, thereby combining the advantages of both the vertical and horizontal technologies.

Claims

1. A testing head (100) having vertical probes, of a type that comprises at least a first and a second plate-like holder (12A, 12B) respectively provided with at least one guide hole (13A, 13B) for receiving at least one contact probe (14), each contact probe having at least one contact tip (15) adapted to establish mechanical and electrical contact to a corresponding contact pad (16) of an integrated electronic device (17) to be tested and being deformed in a deflection region (22) of said probe (14) located between said plate-like holders (12A, 12B) as said contact tip (15) abuts onto said contact pad (16), **characterised in that** said contact probe (14) has, located at said contact tip (15), at least one rigid arm (20) extending laterally from a body (21) of said contact probe (14) and terminating in said contact tip (15), said rigid arm (20) being adapted to offset the contact point of said contact probe (14) with said corresponding contact pad (16) with respect to a longitudinal axis (A-A) of said contact probe (14).

2. Vertical-probe testing head (100) according to Claim 1, **characterised in that** said rigid arm (20) is provided by bending an end portion (H) of said contact probe (14).

3. Vertical-probe testing head (100) according to Claim 1, **characterised in that** the longitudinal axis (B-B) of said rigid arm (20) is substantially perpendicular to said longitudinal axis (A-A) of said contact probe (14).

4. Vertical-probe testing head (100) according to Claim 1, **characterised in that** the longitudinal axis (B-B) of said rigid arm (20) is non-perpendicular to said longitudinal axis (A-A) of said contact probe (14).

5. Vertical-probe testing head (100) according to Claim 1, **characterised in that** said contact tip (15) has a sloping symmetry axis with respect to the longitudinal axis (B-B) of said rigid arm (20).

6. Vertical-probe testing head (100) according to Claim 1, **characterised in that** rigid arms (20) of adjacent contact probes (14) are located in alternatively opposed positions of said guide holes (13A, 13B) with respect to said contact pads (16).

7. Vertical-probe testing head (100) according to Claim 6, **characterised in that** adjacent contact probes (14) have sloping symmetry axis with respect to an alignment axis of said contact pads (16).

8. Vertical-probe testing head (100) according to Claim 7, **characterised in that** said symmetry axis of said contact probes (14) and said alignment axis of said contact pads (16) define an angle equal to 45°.

9. Vertical-probe testing head (100) according to Claim 1, **characterised in that** it comprises contact probes (14) having laterally extended rigid arms (20) with different lengths.

10. Vertical-probe testing head (100) according to Claim 1, **characterised in that** said rigid arm (20) has a slenderised end portion.

11. Vertical-probe testing head (100) according to Claim 1, **characterised in that** said contact probe (14) has a circular cross-section shape.

12. Vertical-probe testing head (100) according to Claim 1, **characterised in that** said contact probe (14) has a non-circular cross-section shape.

13. Vertical-probe testing head (100) according to Claim 1, **characterised in that** said contact probe (14) has a rectangular cross-section shape.

14. Vertical-probe testing head (100) according to Claim 1, **characterised in that** it comprises an air space (23) between at least first (12A) and second (12B) plate-like holders, said air space allowing the deformation of said contact probe (14) as said contact tip (15) abuts on said contact pad (16).

15. Vertical-probe testing head (100) according to Claim 1, **characterised in that** it comprises a plurality of air spaces (23A, 23B) defined by a plurality of plate-like holders (12A, 12B, 12C) and allowing said contact probe (14) to deform as said contact tip (15) abuts against said contact pad (16).

16. Vertical-probe testing head (100) according to Claim 15, **characterised in that** said plate-like holders comprise corresponding guide holes aligned along normal directions to said plate-like holders.

17. Vertical-probe testing head (100) according to Claim 15, **characterised in that** said plate-like holders comprise corresponding guide holes not aligned along normal directions to said plate-like

holders.

18. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** said guide holes (13A, 13B) have straight cross-sectional shapes.

19. Vertical-probe testing head (100) according to any of Claims 1 to 17, **characterised in that** at least one of said guide holes (13A, 13B) has a non-straight cross-sectional shape.

20. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** said contact probe (14) has at least one pre-deformed portion within an air space (23) provided between said at least first (12A) and second (12B) plate-like holders.

21. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** said contact probe (14) has at least one pre-deformed portion provided within said guide holes (13A, 13B).

22. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** said guide holes (13) have a suitable form able to elastically deform said contact probes (14).

23. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** said guide holes (13) have a suitable form which differs from a cross-sectional shape of said contact probes (14) in order to define respective contact points.

24. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** an elastic film is placed over said plate-like holders (12A, 12B) for improving the retention of said contact probes (14) in said guide holes (13A, 13B).

25. Vertical-probe testing head (100) according to any of the preceding claims, **characterised in that** at least one of said plate-like holders comprises guide holes whose axis define a suitable angle (α) with respect to the guide holes of at least another of said plate-like holders in such a way to generate a torsion of said contact probe (14) thus increasing the frictional drag of the probes through the guide holes.

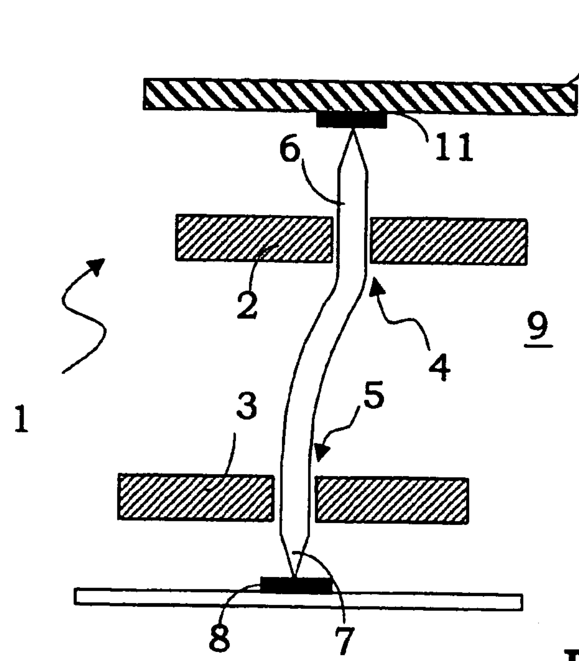

FIG. 1
PRIOR ART

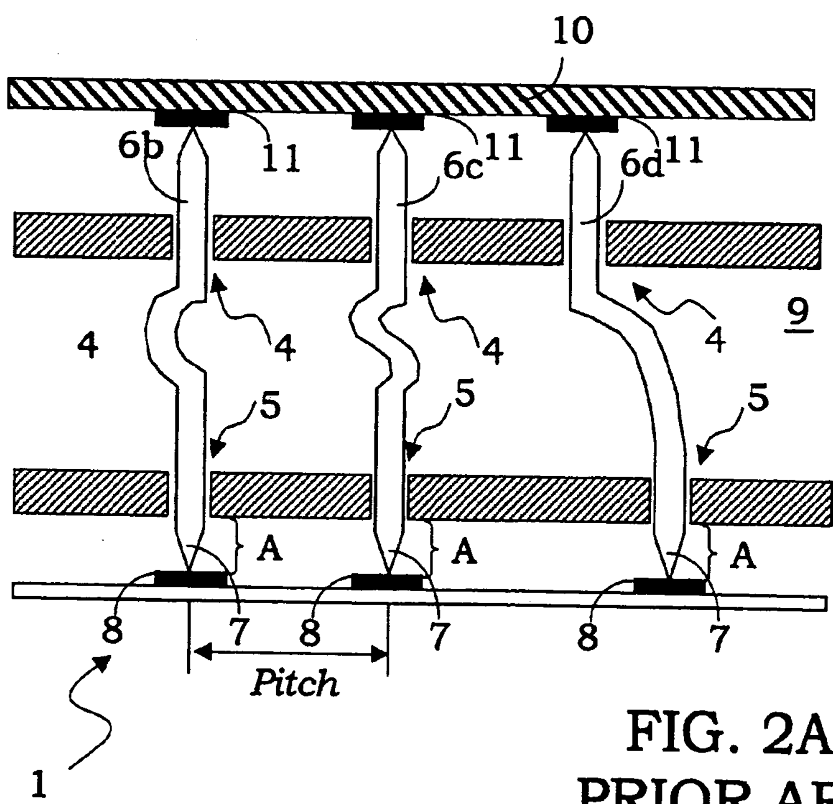

FIG. 2A
PRIOR ART

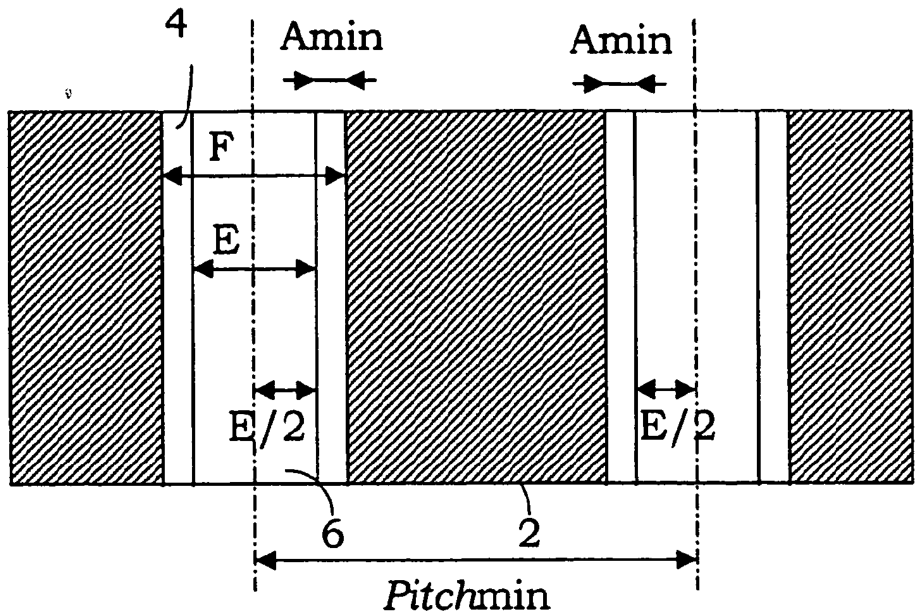

FIG. 2B
PRIOR ART

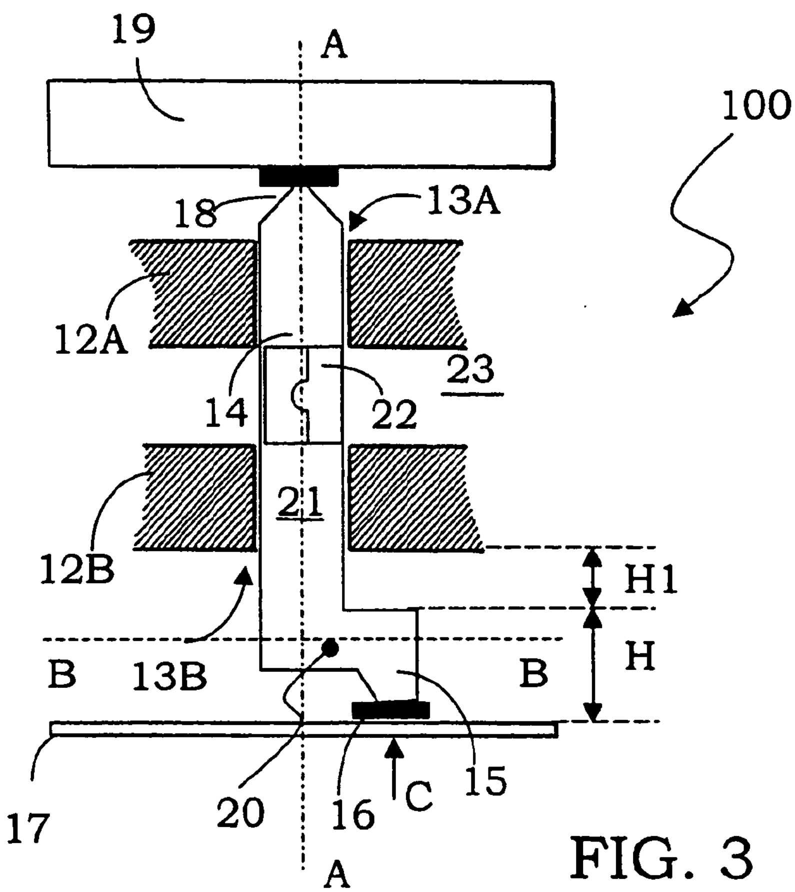

FIG. 3

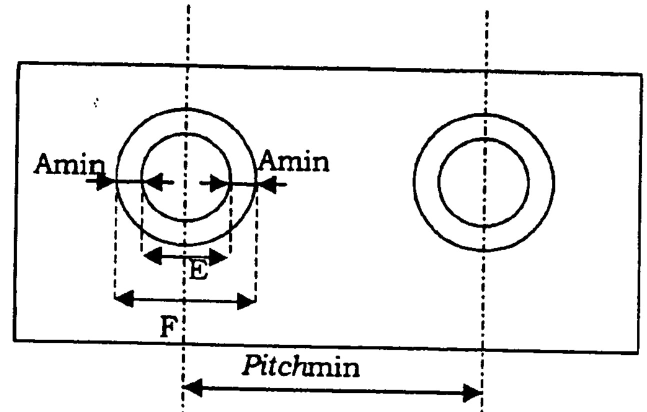

FIG. 2C
PRIOR ART

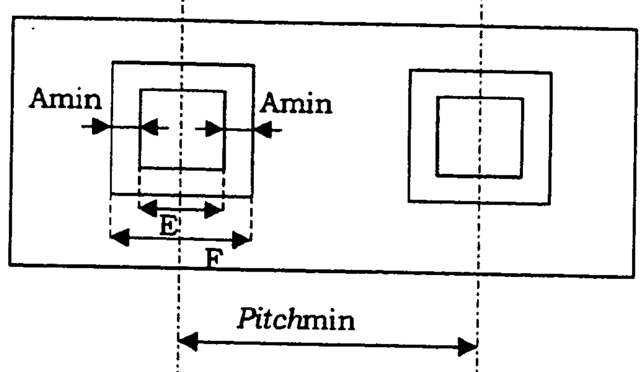

FIG. 2D
PRIOR ART

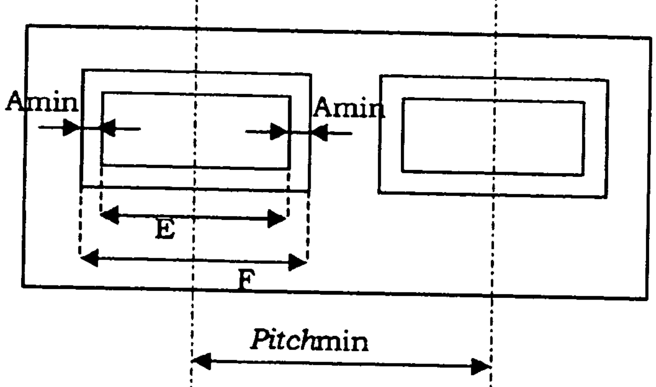

FIG. 2E
PRIOR ART

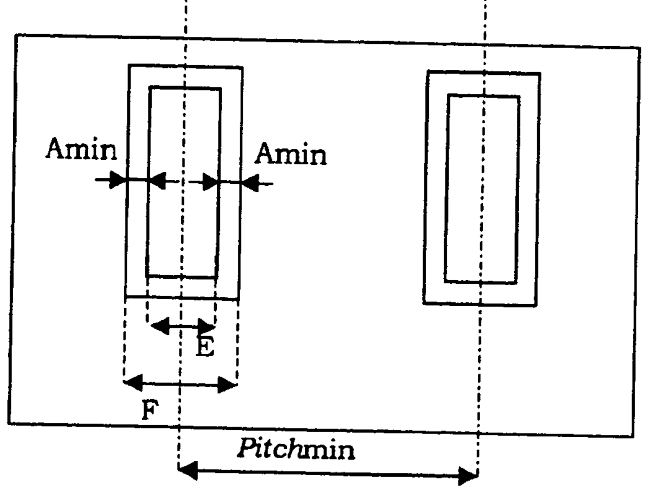

FIG. 2F
PRIOR ART

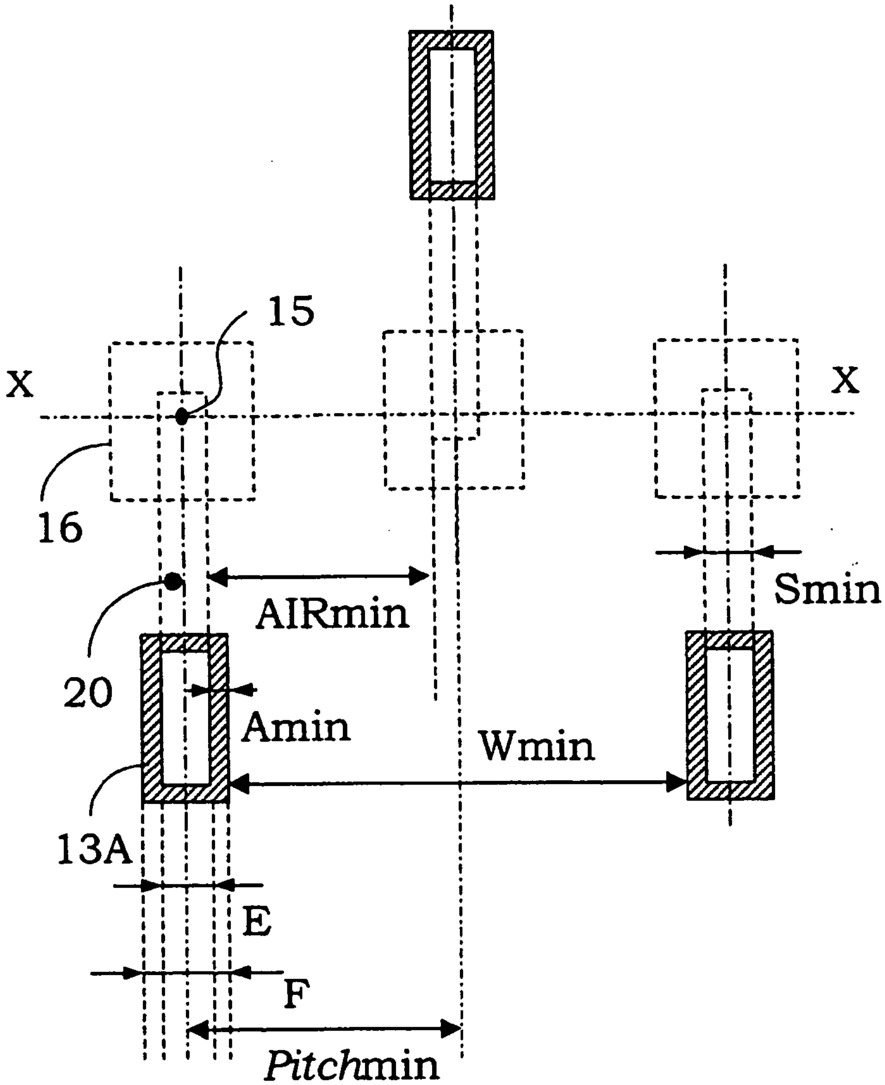

FIG. 4A

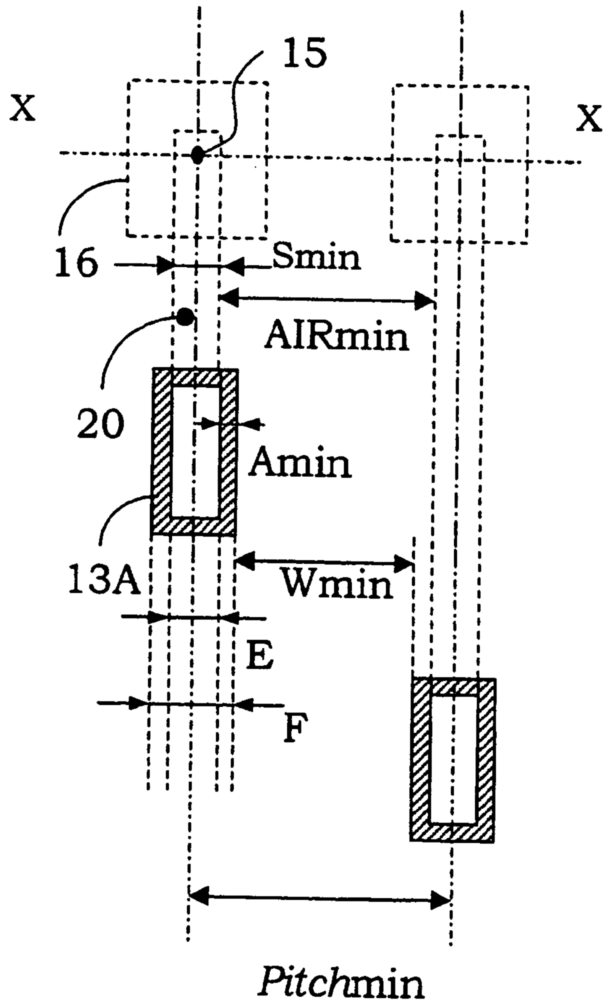

FIG. 4B

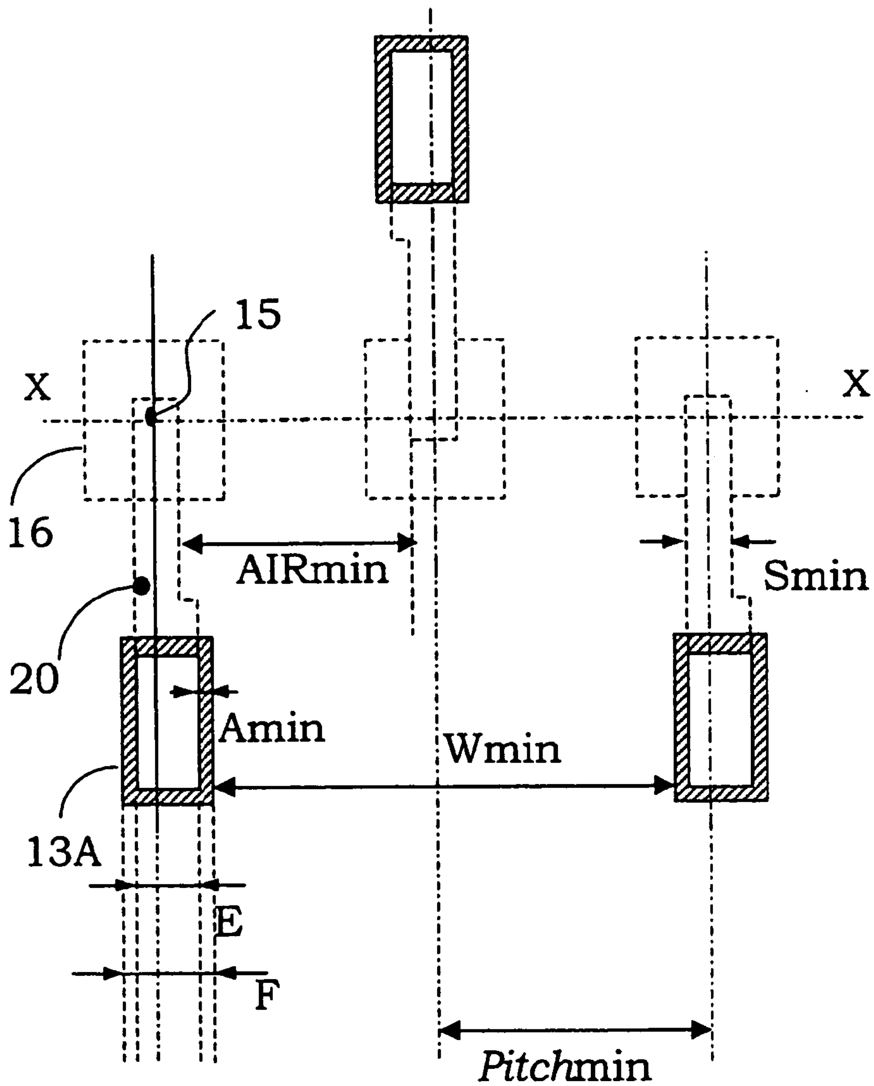

FIG. 4C

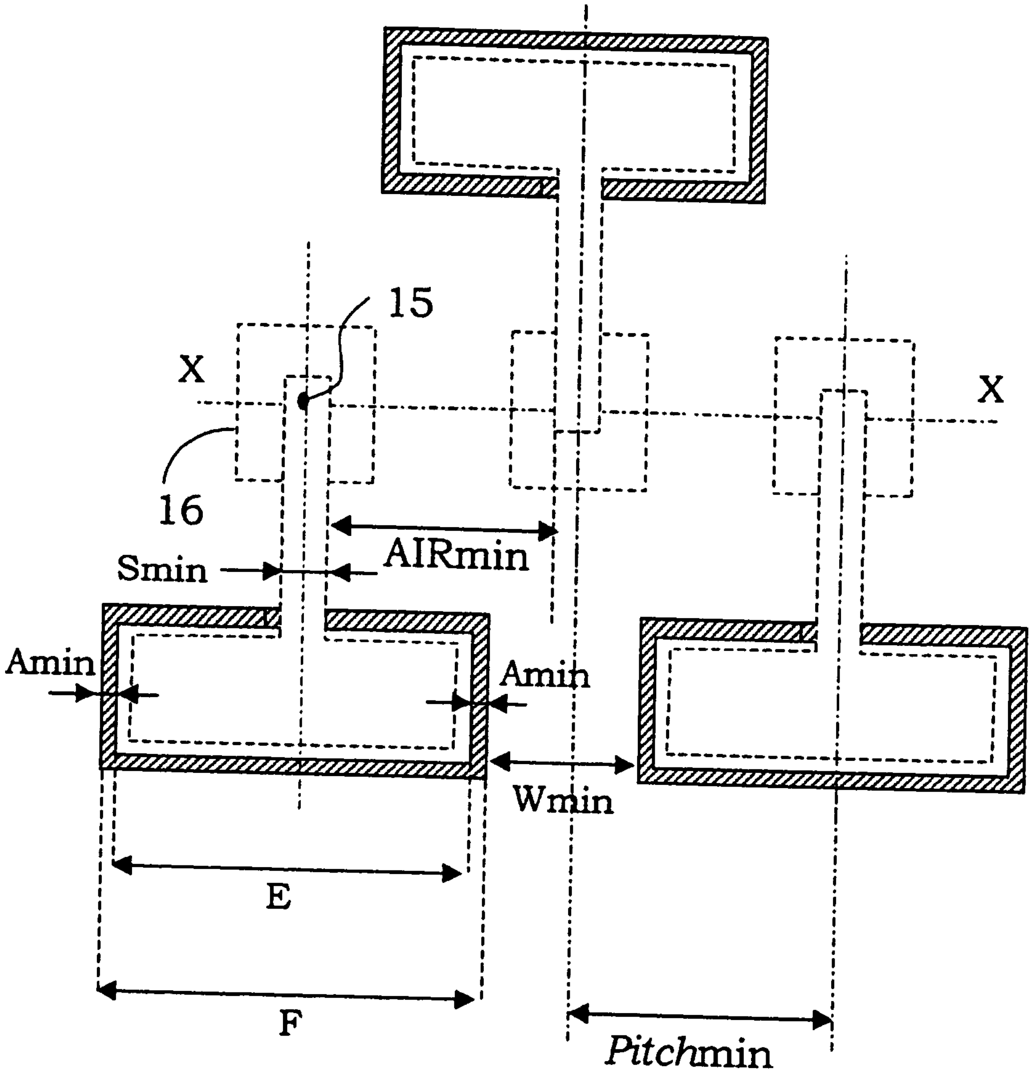

FIG. 4D

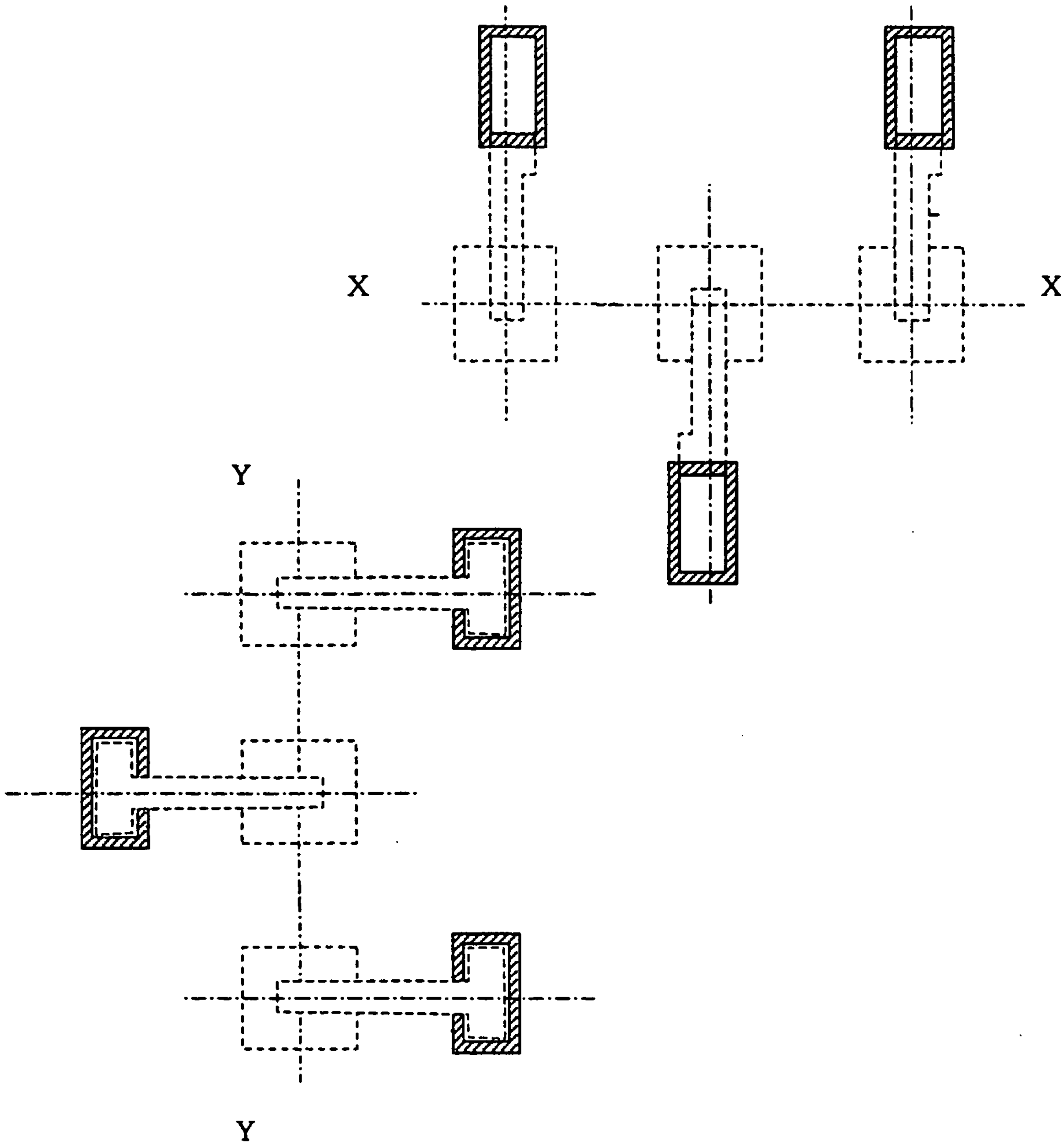

FIG. 4E

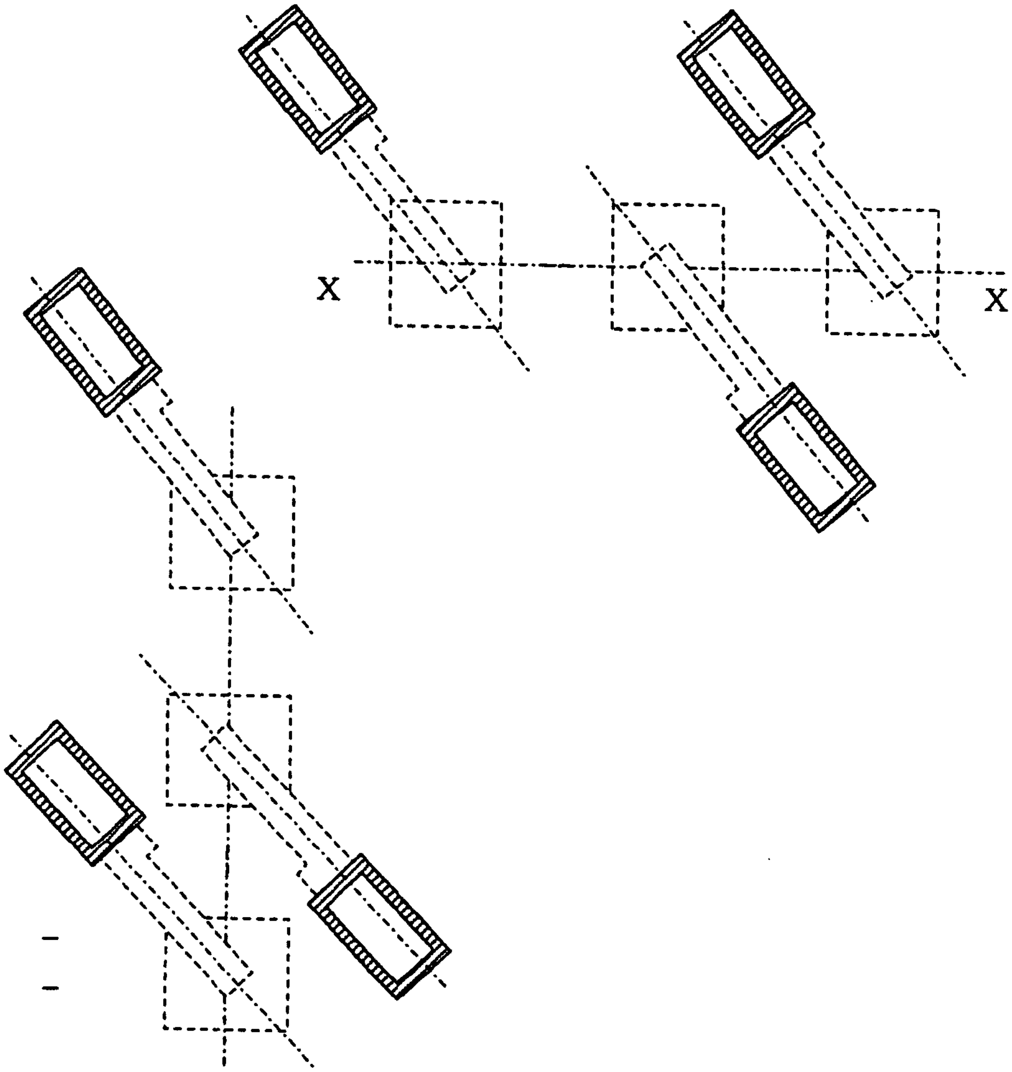

FIG. 4F

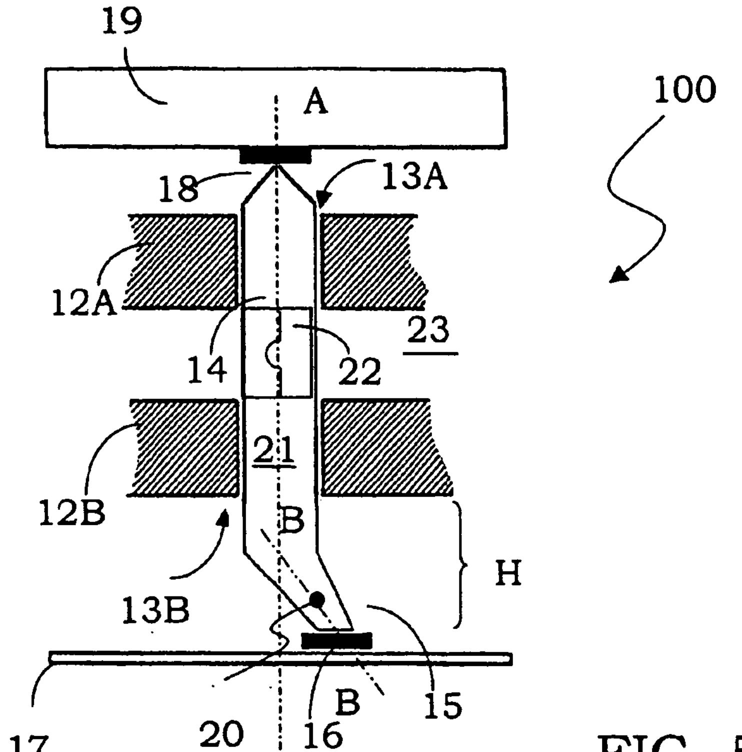
19
A
100
18
13A
12A
23
14
22
21
12B
B
H
13B
17
20
16
B
15
A

FIG. 5

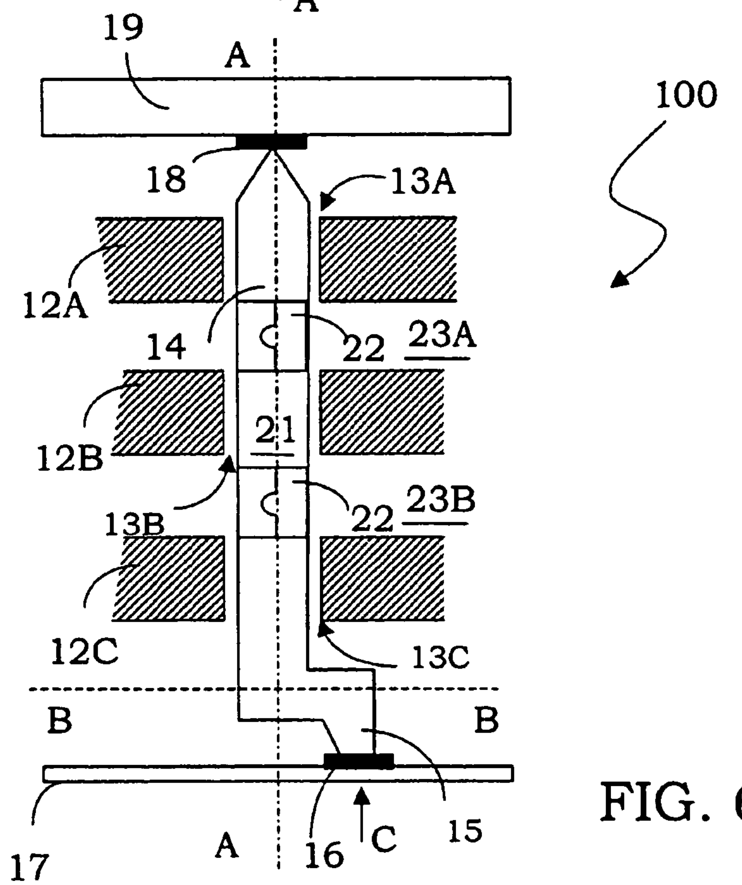
19
A
100
18
13A
12A
14
22
23A
12B
21
13B
22
23B
12C
13C
B
B
17
A
16
C
15

FIG. 6

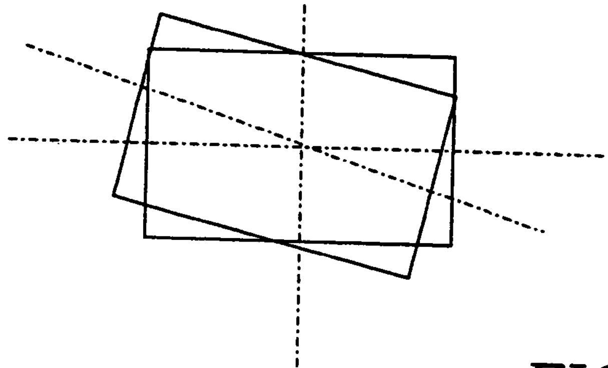

FIG. 7

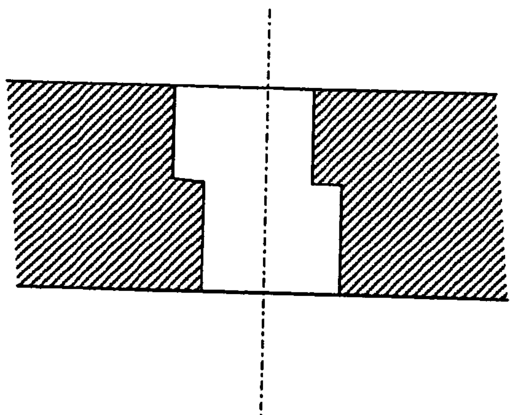

FIG. 8

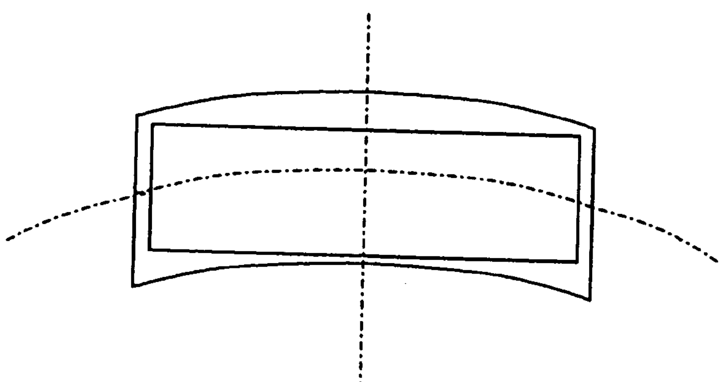

FIG. 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 00 5933

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	WO 99 49329 A (SV PROBE) 30 September 1999 (1999-09-30) * page 3, line 31 - line 34 * * page 7, line 15 - line 23 * * page 11, line 8 - line 30 * * page 12, line 26 - page 13, line 17; figures 1A,1B,3,4 *	1,2,4,5,14,19,20 3,6,7,9-11,18,24	G01R1/073
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 July 2002	Iwansson, K

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